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REVIEWS.

Geology and Mining Industry of the Cripple Creek District, Colorado. By WHITMAN CROSS and R. A. F. PENROSE, JR. Extract from the Sixteenth Annual Report of the Survey, 1894–5. Part II: Papers of an Economic Character.

This report of Messrs. Cross and Penrose is to be classed as one of the most valuable of the publications on economic subjects issued by the Geological Survey. Though less elaborate and accompanied by fewer maps and illustrations than the bulkier monographs of past years, these considerations are largely offset by the timeliness of appearance and the handiness of the separate form in which the report was first issued. For no matter how great the intrinsic merit of the publication or the labor devoted to its preparation, its value lies to a great extent in its appearing at the right time and in a form suitable for ready use, and this particularly with a work relating to mining in a new camp. The report is the outcome of the joint field labors of the authors, prosecuted during three months in the autumn of 1894. It was written, printed, and issued in 1895, and the edition of the separates, as well as of the related Pikes Peak folio, was exhausted before the end of 1896.

The combined report covers about 200 pages of the large octavo size of the annual reports. It is illustrated by thirty-seven figures, seven plates, and one supplementary geological and topographic map which is inserted at the end of the report. The report is divided into two parts. The first, of 109 pages, by Mr. Cross, treats of the general geology and is in great part devoted to the important subject of the petrography of the district; Part second, by Mr. Penrose, deals with the mining geology of the district. The latter is exclusively the subject of this review, Mr. Cross' valuable report requiring the attainments of a specialist for adequate treatment.

Chapter I. of Mr. Penrose's report consists of a brief outline of the history of mining in the camp. Operations were practically begun there in 1891. It is a very remarkable fact, this recent development in a well-known and traveled part of Colorado, within a stone's throw of what has been a much frequented summer resort for years. It is a fact of hopeful suggestion in relation to future discoveries of ore deposits in this country ; but it is a fact also liable to much abuse by promoters as a warrant for the conclusion that gold ores may be found anywhere. It is likewise remarkable that the productive area is included within a district of only six miles square, the area of one township, and, further, as the map shows, a considerable part of this is unproductive ground. The surprising growth of the camp is illustrated by the fact that from an output of only a few thousand tons in 1891, the production increased in the years 1892, 1893, and 1894 to a total variously estimated at from $5,500,000 to $7,000,000. Since that time the growth has continued, and a conservative estimate for the year 1896, kindly furnished by Mr. T. A. Rickard, the geologist for the state, places the value of the production at $9,000,000, and others who are well posted estimate it between $8,000,000 and $9,000,000. During 1895 the value of the output was in the vicinity of $6,500,000. The total for the five years is thus about $22,000,000, or a little less than one-half of the present annual output of gold for the whole country.

It is to be regretted that more space could not have been given in the report to the statistics of the camp. The expense of an assistant for this special work would have been well repaid. The difficulty of obtaining complete and exact figures is undoubtedly great, if not insurmountable; but more could have been gathered than is contained in the two paragraphs of the report, which would have given some idea of the distribution of the shipments both as to time and localities. The difficulty is one which is met with to a greater or less extent in all mining camps of the West, and is partly due to a very natural desire of mine operators not to make their private business public property, especially where no unanimity of action can be secured. Yet such facts are highly valued by mining men and the public and are valuable guides to investors. The gathering of complete statistics would do much towards placing mining on a sound basis. Public effort could well be exerted in this direction and provision made for the collection of such statistics by judicious legislation.

Chapter III is devoted to the ores of the camp, or more precisely to the minerals of the ore deposits. As Dr. Penrose says in his summary, the ores consist of the country rock, more or less completely replaced by quartz, with fluorite, opaline silica, and kaolin, and containing iron pyrites, and other sulphides, as well as various other minerals in limited quantities.

Gold is the only metal which occurs in amounts of commercial value. It is found normally as a telluride, or in a free state as a result of the oxidation of the former. It is possible that some of the gold is present as auriferous iron pyrites, but this must be quite rare as most of the pyrites is valueless, and, as a rule in the camp, rock impregnated with this mineral is considered of little significance.

The free gold appears to be confined to zones of oxidation and these frequently extend to depths of several hundred feet. It is generally in a very fine condition, but sometimes pieces up to a quarter of an inch in size are found. It is usually rusty, but is otherwise remarkably pure, with hardly any appreciable silver, even less than is found in the telluride ores. The telluride of gold appears to be principally the mineral calaverite, according to examinations made by Mr. W. F. Hillebrand and Dr. S. L. Penfield; but there is probably also some sylvanite and other compounds.

Silver occurs only in very small quantities in most of the ores, though at the Blue Bird and a few other mines it has been found in considerable amounts, though not enough to make any showing in the production of the camp.

As an accessory mineral, galena has been found at a number of places, but in small quantities. Some spahlerite occurs at a few mines. Copper minerals are extremely rare, as are antimony compounds also. Fluorite is common in many ores and is frequently prominent by reason of the coloration it gives to the rocks. It is sometimes intimately associated with quartz. Quartz is the most common secondary mineral. It is sometimes found in bodies and occurs also as well-defined quartz veins, but more frequently it is homogeneously disseminated throughout the ore or country rock, simply making them harder. Such silicified rock is often confused with dikes by the miners.

Kaolin is common along fissures, resulting from decay of the feldspar of the eruptives; it is either white or stained a brown or black color. Calcite is not abundant and occurs lining the face of rocks or filling small cavities. Gypsum, though not of frequent occurrence, is found in bodies of some size in one mine. Barite and other minerals also occur in small quantities.

Superficial alteration of the rocks is apparent to depths of 300 and 400 feet with the usual effects of hydration, oxidation, and leaching.

The value of the ores shipped varies from $20 to $400 per ton; an average is perhaps between $50 and $85. During the first year's operation, the camp was essentially a shipper of high-grade ores. Recently, however, there has been a change with the establishment of a number of cyanide and chlorinating plants, which has reduced treatment charges to $7.50 per ton. It is to be feared, however, that an understanding between the managers of these plants will prevent a further reduction in these charges, if it does not cause an increase over the above rate. It is of great importance to the future of the camp that low freight and treatment charges be reached and maintained as otherwise great quantities of low-grade ores will have to be thrown aside. Any such movement, therefore, to maintain high charges is to be opposed and may seriously damage the camp.

Chapter III deals with the mode of occurrence of the ores. This subject is one of special value and interest here. It is well summarized in the statement of the first paragraph, which is to the effect that the ores generally occur in fissures in the country rock, which usually represent slight faulting and that the veins have been formed mostly by replacement along these fissures and not by the filling of open gaps. Indeed, there is often no cavity recognizable and little, if any evidence of one ever having existed, the solutions apparently having filled the imperceptible space between the flat joint or fault planes of the rock, the gold minerals having been deposited on the surface and the rock itself having been merely silicified. Thus, in these deposits, the scrapings from such surfaces often run very high in gold, while the rock itself is valueless. This is a very peculiar form of deposit and is almost exclusively confined to this district.

The deposits occur in a region of Tertiary volcanic breccias or tuffs. The breccias are cut by numerous bodies of intrusive eruptive rocks, such as phonolite and andesite, and they also surround eruptive masses which are older than the breccia. The latter are themselves surrounded by what Cross terms the granite-gneiss complex of the Colorado range. The dikes intersect all of these rocks, passing from granite into breccia, and they also intersect each other. They are evidence of several epochs of fissuring. The veins also intersect all these rocks in their courses. The vein fissures seem to be later than the dikes, though some were apparently formed at the same time.

The courses of both vary from northeast to northwest, but there are exceptions to this rule.

The fissures are not open gaps, as already stated, but are closed lines of fracture along which replacement has occurred. In Dr. Penrose's words: "Sometimes there are two or more main parallel cracks or fissures and numerous minor ones, while very commonly the zone of fracturing seems to be represented by no especially well-defined break, but by numerous parallel or approximately parallel cracks, each of about the same magnitude and from a fraction of an inch to several feet apart." . . . . "In fact the district may be regarded as an area intersected by numerous zones of fissuring which are separated by an area of less marked but very noticeable fissuring." The ore is found lining both sides of the fissures.

Faulting is evidenced by grooves and slickensided rock surface. The movements were small in amount, the greatest observed being between twenty and twenty-five feet.

The minerals of the ore bodies are generally promiscuously arranged, the ore usually being simply the country rock containing greater or less amounts of secondary minerals. Ore is found along some of the fissures or cracks, while others, almost identical in appearance, are barren. These fissures are often taken by miners for vein walls beyond which no ore will be found. They hence neglect to cross cut. Dr. Penrose gives a valuable suggestion in advising miners not to be misled by these apparent walls, as valuable deposits will often be found within a short distance beyond them. As an illustration, in a mine operated by the writer about a dozen such fissures, variously mineralized, were encountered in a cross cut of about 100 feet.

A noticeable feature of this camp is that the veins follow the dikes, either in contact, or more commonly in proximity to them. Sometimes they cross the dikes and follow them on different sides. The association of dikes and veins is a fact well known by mining men and the presence of a dike, especially of phonolite, causes a claim to be held in much higher estimation.

In their mode of occurrence the dikes and fissures give evidence of a limited erosion of the district. Thus their upper parts often differ markedly from their deeper parts. "The dip near the surface is frequently at a different angle from that at a depth, and veins which occur in one well-defined fissure at a depth sometimes fork near the surface and appear in separate outcrops. Both these phenomena can be attributed to the fact that at a depth the fissures occupied by the dikes or veins were confined to the original line of breakage on account of the superincumbent pressure, while nearer the surface this pressure was relieved and numerous transverse breaks of more or less superficial character were encountered and the fissures were more easily deflected and divided."

It is of special importance with these deposits to distinguish between shrinkage cracks and fissures, both along dikes and elsewhere. The reason for this is that fissures are more persistent and likely to extend to greater depths than are shrinkage cracks.

The ore of the veins, as elsewhere, occurs in chutes. That is, certain parts of the fissures are barren while others contain ore of value. These chutes are of greater vertical than horizontal dimensions. They differ from the chutes generally recognized in other mining regions in being isolated bodies of ore along the fissure planes, rather than rich portions of otherwise clearly defined veins. They vary in breadth from one to several hundred feet, and from a few inches to several feet in width. Their distribution is not influenced by a difference in country rock, as that is uniform. They are probably due more to the location of cross fractures and fissures, and to localization of the ore-bearing solution. They are also affected by the distribution of the dikes.

Chapter IV treats of the source and mode of deposition of the ores.

The ore, Dr. Penrose concludes, was probably derived from both deep and shallow sources, from the whole area tributary to the fissures. An investigation of the actual gold contained in the country rocks was not made, but the metal doubtless exists in both the old and new formations, though he is of the opinion that the later eruptives were probably the most prominent source, as in them the conditions for concentration were best realized, as they were in the neighborhood of volcanic vents where the rocks were penetrated by hot waters impregnated with the mineral solutions. The solution and deposition of gold along with quartz from alkaline solution is readily understood, but the formation of the telluride of gold requires further investigation before it can be explained.

As regards the associated minerals, the fluorite was probably evolved from the phonolite magmas, in a volatile or soluble form, and acted on solutions carrying lime; if it was in the form of hydrofluorsilic acid, the association of the quartz with the fluorite is readily explained.

The fluorite has possibly also some connection with the presence of the telluride, as fluorite is common elsewhere where telluride ores occur.

The ore constituents were probably introduced in a liquid form, probably hot and probably hastened by steam and other vapors. The process of deposition was largely one of replacement; this may have been by chemical action or by deposition in minute cavities after the removal of constituents of the country rock. The latter Dr. Penrose thinks more probable. The deposition was caused principally by chemical reaction with other solutions rather than by reaction with the country rock.

It is to be regretted that a direct investigation of the problems of the source of the ores and their mode of deposition could not have been made. The study given to the subject is confessed to have been inadequate for final results. Though the conclusions reached by the author seem quite probable, they can be classed only as probabilities pending complete inquiry.

As a final criticism of this in so many respects valuable and excellent report, the cuts or the figures illustrating it might have been improved upon. They are somewhat too diagrammatic and most of them seem to be more of illustrations of the writer's ideas than actual sketches "from life" in the mine. This does not apply to all of the figures, nor to the small mine maps or plates which are inserted. These are excellent and appear to have been carefully compiled from the mine surveys.

ARTHUR WINSLOW.

TELLURIDE, COL.,
January 5, 1897.

Glacier Bay and its Glaciers. By HARRY FIELDING REID. United States Geological Survey, 16th Annual Report, 1894–5, pp. 415–461. Plates LXXXVI–XCVI.

The studies of Muir glacier conducted by Professor Reid in the summer of 1890, and the results published in the *National Geographic Magazine*, Vol. IV, were continued and extended in the summer of 1892 and the results recorded in the report named above. During the earlier expedition, attention was restricted to Muir glacier and its tributaries, of which an excellent map was published; the later expedition had for its main object the exploration of the western extension of Glacier Bay with its numerous inlets and many glaciers.